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**GRID AND CQUAD, TWO PREPROCESSING
CODES FOR NASTRAN**

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I. INTRODUCTION

The NASTRAN^{1,2} (NASA Structural Analysis) finite element program is a general-purpose, digital, structural-analysis computer program which uses the finite element method to analyze the behavior of elastic structures. This computer program is in use at the Ballistic Research Laboratory (BRL) on the UNIVAC 1108. Among the problems requiring solution at the BRL are many that involve rectangular plates and membranes. Some of the problems require the generation of a two-dimensional grid while others may require a three-dimensional grid. Some problems require using the CQUAD2 plate elements to obtain a solution. If the plate is large, a great number of grid points and CQUAD2 elements may be needed to adequately define the structure. The result is a considerable amount of figuring, writing and then punching of cards, all of which is time-consuming and error-prone for large systems. Such a large problem resulted in two programs, GRID and CQUAD, being designed to generate the required two-dimensional grid and the CQUAD2 connecting elements, respectively, and to punch the cards required for the grid and element input. The GRID program was subsequently modified to be able to generate a three-dimensional grid.

II. DISCUSSION

The GRID program is listed in Figure 1. The input to the program consists of two cards. The first card gives A, B, and C, the x, y, and z spacings of the grid, respectively, in FORMAT (3F10.4). The second card gives X9, Y9, and Z9, the x, y, and z dimensions of the grid, in the same format. In the program, the two formats are given different numbers to leave open the option of changing the format of one of the sets in a simple manner. As may be noted the fields 3, 7, and 8 are left blank since they can be specified on a GRDSET card, or permanent single-point constraints associated with specific grid points could be punched in later. Fields 3 and 7 refer, respectively, to the identification number of the coordinate system in which the grid point is defined and to the identification number of the coordinate system in which the displacements are measured at the grid point; field 8 contains the single-point constraints that are to restrict the motion of the grid point. If a two-dimensional grid is desired then Z9 is left blank, and the program will then generate a two-dimensional grid and punch out the appropriate GRID cards. If the uniform spacing does not cover the range of the grid exactly, then the remainder is placed at the end; i.e., 2.75 units if a 1-unit spacing is specified would result in two 1-unit spacings and the last one with a 0.75 spacing. This is true for each of the dimensions, x, y, and z. Figure 2 gives the resultant grid listing where a three-dimensional grid had X9, Y9, Z9, A, B, and C

¹The NASTRAN Theoretical Manual, NASA SP-222(01), December 1972

²The NASTRAN User's Manual, NASA SP-22(01), May 1973

```

PROGRAM GRID(INPUT,OUTPUT,PUNCH,TAPE5=INPUT,
1TAPE6=OUTPUT,TAPE7=PUNCH)
C   X9,Y9,Z9 ARE THE X,Y, AND Z DIMENSIONS OF
C   THE PLATE. IF A TWO DIMENSIONAL GRID IS
C   DESIRED, PUT A ZERO IN FOR Z9. A,B,C ARE
C   THE UNIFORM DIMENSIONS OF THE ELEMENTS IN
C   THE X,Y,Z DIRECTIONS, RESPECTIVELY. IF THE
C   GRID DOES NOT COME OUT EVEN IN ANY DIRECTION
C   THEN THE REMAINDER IS PUT IN THE LAST
C   INCREMENT OF THAT DIRECTION. IT IS THERE-
C   FORE PREFERABLE TO SELECT A,B, AND C TO
C   MAKE THE GRID SPACINGS UNIFORM OVER THE
C   ENTIRE GRID.
    INTEGER D,E,F,S
    READ(5,50)A,B,C
50  FORMAT(3F10.4)
    WRITE(6,50)A,B,C
    X=0
    Y=0
    Z=0
    READ(5,51)X9,Y9,Z9
51  FORMAT(3F10.4)
    WRITE(6,51)X9,Y9,Z9
    S=1
120  FORMAT(8H GRID      ,I8,8X,3F8.3)
    L=INT(X9/A+1)
    M=INT(Y9/B+1)
    N=1
    D=M
    IF(Z9.EQ.0)GO TO 168
    N=INT(Z9/C+1)
168  CONTINUE
    DO 200 K=1,N
    X=0
    Y=0
169  CONTINUE
170  DO 400 J=1,M
179  X=0
180  CONTINUE
    DO 500 I=1,L
    WRITE (6,120)S,X,Y,Z
    WRITE (7,120)S,X,Y,Z
    S=S+1
    X=X+A

```

Figure 1. Listing of GRID Program.

```

500 CONTINUE
    X=X-A
    IF (X.NE.X9)GO TO 503
    GO TO 504
503 X=X9
    WRITE (6,120)S,X,Y,Z
    WRITE (7,120)S,X,Y,Z
    S=S+1
504 Y=Y+B
400 CONTINUE
    Y=Y-B
    IF(Y.EQ.Y9)GO TO 190
    CONTINUE
402 Y=Y9
    M=1
    GO TO 170
190 Z=Z+C
    M=D
200 CONTINUE
    Z=Z-C
    IF(Z.EQ.Z9)GO TO 700
    Z=Z9
    M=D
    N=1
    GO TO 168
700 STOP
701 END

```

Figure 1 Continued. Listing of GRID Program.

GRID	1	0.000	0.000	0.000
GRID	2	1.000	0.000	0.000
GRID	3	2.000	0.000	0.000
GRID	4	2.750	0.000	0.000
GRID	5	0.000	1.000	0.000
GRID	6	1.000	1.000	0.000
GRID	7	2.000	1.000	0.000
GRID	8	2.750	1.000	0.000
GRID	9	0.000	2.000	0.000
GRID	10	1.000	2.000	0.000
GRID	11	2.000	2.000	0.000
GRID	12	2.750	2.000	0.000
GRID	13	0.000	2.500	0.000
GRID	14	1.000	2.500	0.000
GRID	15	2.000	2.500	0.000
GRID	16	2.750	2.500	0.000
GRID	17	0.000	0.000	1.000
GRID	18	1.000	0.000	1.000
GRID	19	2.000	0.000	1.000
GRID	20	2.750	0.000	1.000
GRID	21	0.000	1.000	1.000
GRID	22	1.000	1.000	1.000
GRID	23	2.000	1.000	1.000
GRID	24	2.750	1.000	1.000
GRID	25	0.000	2.000	1.000
GRID	26	1.000	2.000	1.000
GRID	27	2.000	2.000	1.000
GRID	28	2.750	2.000	1.000
GRID	29	0.000	2.500	1.000
GRID	30	1.000	2.500	1.000
GRID	31	2.000	2.500	1.000
GRID	32	2.750	2.500	1.000
GRID	33	0.000	0.000	1.750
GRID	34	1.000	0.000	1.750
GRID	35	2.000	0.000	1.750
GRID	36	2.750	0.000	1.750
GRID	37	0.000	1.000	1.750
GRID	38	1.000	1.000	1.750
GRID	39	2.000	1.000	1.750
GRID	40	2.750	1.000	1.750
GRID	41	0.000	2.000	1.750
GRID	42	1.000	2.000	1.750
GRID	43	2.000	2.000	1.750
GRID	44	2.750	2.000	1.750
GRID	45	0.000	2.500	1.750
GRID	46	1.000	2.500	1.750
GRID	47	2.000	2.500	1.750
GRID	48	2.750	2.500	1.750

Figure 2. Three-Dimensional Grid Generated by GRID Program.

specified as 2.75, 2.5, 1.75, 1.0, 1.0, and 1.0. Figure 3 gives the resultant grid listing where a two-dimensional grid had X9, Y9, Z9, A, B, and C specified as 3.75, 7.75, blank, 1.0, 1.0, and blank.

Figure 4 gives the listing of the CQUAD program. The input to the program consists of 3 integers in FORMAT (3I10), giving the total number of grid points in the mesh, the number of grid points in the x direction and the identification number of the PQAD2 property card. Field 8, the material property orientation angle, is left blank. The CQUAD program creates the grid connections in a counter-clockwise direction around the perimeter of each element and numbers the elements from one to the total number of CQUAD2 elements. Figure 5 gives a listing of the CQUAD2 cards generated using the grid from Figure 3.

III. CONCLUSION

The two programs have been tested on the CYBER 7600 for two- and three-dimensional grids and for the dimensions being exact numbers of intervals and for grids having dimensions not an exact number of intervals. The CQUAD program was also tested on the CYBER 7600. Use of these programs will reduce both time, labor, and the probability of error.

ACKNOWLEDGEMENTS

Thank you to Dr. George Klem for the initial transcription from BASIC to FORTRAN and to Mr. George Francis for debugging aid. The staff of the CYBER 7600 were as usual helpful in expediting runs.

GRID	1	0.000	0.000	0.000
GRID	2	1.000	0.000	0.000
GRID	3	2.000	0.000	0.000
GRID	4	3.000	0.000	0.000
GRID	5	3.750	0.000	0.000
GRID	6	0.000	1.000	0.000
GRID	7	1.000	1.000	0.000
GRID	8	2.000	1.000	0.000
GRID	9	3.000	1.000	0.000
GRID	10	3.750	1.000	0.000
GRID	11	0.000	2.000	0.000
GRID	12	1.000	2.000	0.000
GRID	13	2.000	2.000	0.000
GRID	14	3.000	2.000	0.000
GRID	15	3.750	2.000	0.000
GRID	16	0.000	3.000	0.000
GRID	17	1.000	3.000	0.000
GRID	18	2.000	3.000	0.000
GRID	19	3.000	3.000	0.000
GRID	20	3.750	3.000	0.000
GRID	21	0.000	4.000	0.000
GRID	22	1.000	4.000	0.000
GRID	23	2.000	4.000	0.000
GRID	24	3.000	4.000	0.000
GRID	25	3.750	4.000	0.000
GRID	26	0.000	5.000	0.000
GRID	27	1.000	5.000	0.000
GRID	28	2.000	5.000	0.000
GRID	29	3.000	5.000	0.000
GRID	30	3.750	5.000	0.000
GRID	31	0.000	6.000	0.000
GRID	32	1.000	6.000	0.000
GRID	33	2.000	6.000	0.000
GRID	34	3.000	6.000	0.000
GRID	35	3.750	6.000	0.000
GRID	36	0.000	7.000	0.000
GRID	37	1.000	7.000	0.000
GRID	38	2.000	7.000	0.000
GRID	39	3.000	7.000	0.000
GRID	40	3.750	7.000	0.000
GRID	41	0.000	7.750	0.000
GRID	42	1.000	7.750	0.000
GRID	43	2.000	7.750	0.000
GRID	44	3.000	7.750	0.000
GRID	45	3.750	7.750	0.000

Figure 3. Two-Dimensional Grid Generated by GRID Program.

```

C      G9 IS THE TOTAL NUMBER OF GRID POINTS AND
C      G8 IS THE NUMBER OF GRID POINTS IN THE X
C      DIRECTION. P IS THE PROPERTY ID FOR THE
C      CQUAD2 ELEMENT.
      INTEGER S,P,O,Q,G9,G8
      S=0
      M=0
      READ(5,50)G9,G8,P
      WRITE(6,50)G9,G8,P
70     INDEX=G8-1
      DO 200 I=1,INDEX
      S=S+1
      M=M+1
      N=M+1
      O=N+G8
      Q=O-1
      WRITE(6,20)S,P,M,N,O,Q
      WRITE(7,21)S,P,M,N,O,Q
200    CONTINUE
      IF(O.EQ.G9)GO TO 180
      M=M+1
      GO TO 70
180    STOP
21    FORMAT(8HCQUAD2 ,6I8)
20    FORMAT(9H CQUAD2 ,6I8)
50    FORMAT(3I10)
      END

```

Figure 4. Listing of CQUAD Program.

CQUAD2	1	2	1	2	7	6
CQUAD2	2	2	2	3	8	7
CQUAD2	3	2	3	4	9	8
CQUAD2	4	2	4	5	10	9
CQUAD2	5	2	6	7	12	11
CQUAD2	6	2	7	8	13	12
CQUAD2	7	2	8	9	14	13
CQUAD2	8	2	9	10	15	14
CQUAD2	9	2	11	12	17	16
CQUAD2	10	2	12	13	18	17
CQUAD2	11	2	13	14	19	18
CQUAD2	12	2	14	15	20	19
CQUAD2	13	2	16	17	22	21
CQUAD2	14	2	17	18	23	22
CQUAD2	15	2	18	19	24	23
CQUAD2	16	2	19	20	25	24
CQUAD2	17	2	21	22	27	26
CQUAD2	18	2	22	23	28	27
CQUAD2	19	2	23	24	29	28
CQUAD2	20	2	24	25	30	29
CQUAD2	21	2	26	27	32	31
CQUAD2	22	2	27	28	33	32
CQUAD2	23	2	28	29	34	33
CQUAD2	24	2	29	30	35	34
CQUAD2	25	2	31	32	37	36
CQUAD2	26	2	32	33	38	37
CQUAD2	27	2	33	34	39	38
CQUAD2	28	2	34	35	40	39
CQUAD2	29	2	36	37	42	41
CQUAD2	30	2	37	38	43	42
CQUAD2	31	2	38	39	44	43
CQUAD2	32	2	39	40	45	44

Figure 5. CQUAD2 Elements Generated by CQUAD Program for Grid of Figure 3.

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